M.H.
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Klaproth

Cornwall

Smithsonian Bequest.

From the Translator.

Fig. 1.

Fig. 2.

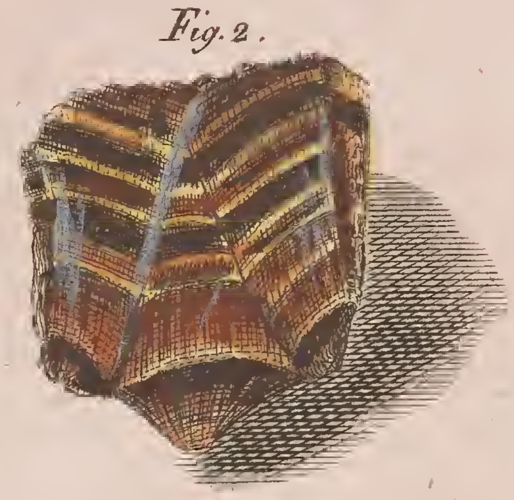

Fig. 3.

OBSERVATIONS

RELATIVE TO THE

MINERALOGICAL AND CHEMICAL HISTORY

OF THE

FOSSILS OF CORNWALL.

By MARTIN HENRY KLAPROTH,

ASSESSOR OF THE COLLEGE OF PHYSICIANS AND APOTHECARIES, AND EXTRAORDINARY MEMBER OF THE FRIENDLY SOCIETY OF INQUIRERS INTO NATURE, OF BERLIN.

TRANSLATED FROM THE GERMAN

By JOHN GOTTLIEB GROSCHKE, M. D.

PROFESSOR OF NATURAL HISTORY IN THE COLLEGE OF MITAU.

LONDON:

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M.DCC.LXXXVII.

TO

HIS EXCELLENCY,

BARON DE OFFENBERG,

MARSHAL TO THE COURT OF HIS SERENE HIGHNESS THE DUKE OF COURLAND,

KNIGHT OF THE ORDERS OF THE LION AND OF ST. JOHN, &c. &c. &c.

THE FOLLOWING WORK

IS INSCRIBED,

AS A TESTIMONY OF ESTEEM AND AFFECTION,

BY

THE TRANSLATOR.

ADVERTISEMENT.

THE work of which a tranſlation is now preſented to the public, was publiſhed about two months ago in the Schriften Natur-Forſchender Freunde, of Berlin. The Author of it is diſtinguiſhed in Germany for the extent and accuracy of his Chemical and Mineralogical knowledge; and nothing more than his being known ſeems neceſſary to procure him a ſimilar diſtinction in other countries.

The Tranſlator confeſſes that one object of his undertaking has been to make Mr. Klaproth's merit more generally known; at the ſame time he perſuades himſelf that his performance

may

may be of ſome amuſement and uſe to the Engliſh Naturaliſt, in giving him a more accurate deſcription and analyſis of minerals of his own country, than has yet appeared in the Engliſh language. He would hope too that it may render ſome ſervice to the ſciences of Chemiſtry and Mineralogy, the intereſts of which cannot fail to be promoted, by diffuſing the knowledge of every thing which reſpects them; it may, accidentally, perhaps, increaſe the number of thoſe who ſtudy theſe ſciences, and excite a ſpirit of greater diligence and preciſion in reſearches connected with them.

The Tranſlator is not certain, whether it may not be proper for him to ſay ſomething by way of vindication of the Author, and ſomething by way of apology

logy for himſelf. Though he is not aware of any error in the ſketch of the Natural Hiſtory of Cornwall, which is given in the following work, that ſketch would certainly have been more full, and it might have been more exact, if the Author had had the benefit of ſeeing the country, the minerals of which he deſcribes. As he was without that advantage, he has been obliged to depend upon the relations of others, and his own collection of Minerals. But both of theſe the Tranſlator has the beſt reaſon for believing have been remarkably accurate and complete. If, however, there ſhould be any imperfection in this part of the Author's work, he is confident it has been unavoidable, and cannot therefore be imputed to the Author as a fault.

He

He wiſhes he could believe that his own apology was not more neceſſary than the Author's vindication; but he is very ſenſible that the tranſlation has many defects, and defects which are not eaſily excuſed. It may not, however, be unreaſonable to expect ſome indulgence to the work of a foreigner, who, during a ſhort ſtay in England, has been able to form only an imperfect acquaintance with the Engliſh language; and the tranſlation of a work of ſcience ſhould not, perhaps, be abſolutely condemned, if it be ſufficiently perſpicuous to convey the meaning of the original, although it be deficient in eaſe and in elegance.

London,
Nov. 10, 1786.

INTRODUCTION.

THE County of Cornwall claims the peculiar attention of mineralogifts, on account of its fubterraneous natural productions. No country in the world can boaft of mines more ancient, or productive for a longer period. For before the time of Herodotus, the Phœnicians, and after them the Greeks, brought tin from this country, which, on that account, was named by the latter nation Caffiterios, or the Tin-ifland: and with refpect to the prefent richnefs of thefe mines, inftances will be given in the courfe of this work, of the profit of fingle mines, which fhew, that it is not an exaggerated account which Mr. Jars gave in the year 1770, that the value of the annual produce of the tin-mines amounts from 190 to 200,000

 pounds,

pounds, and of thoſe of copper to 140,000 pounds ſterling; and there is ſtill an abundant ſtore of both metals to laſt for many centuries.

The peculiarity of moſt of the Corniſh foſſils affords the naturaliſt a fruitful ſubject of enquiry, and rich materials for the increaſe of geological and mineralogical knowledge. Becher, perhaps, the moſt experienced mineralogiſt and miner of his time, who had ſtudied ſubterraneous nature in the mines of Hungary and Germany for many years, acknowledges freely that he ſtill found a great deal to learn in Cornwall. He expreſſes himſelf (in the remarkable dedicatory epiſtle to the famous Boyle, of his Mineralogical Alphabet, which he wrote at Truro, in Cornwall,) in the following manner: " The earth is here ſo abundant in different kind of foſſils, that I believe there is no place in the world which excels Cornwall in the quantity and variety of them: and I confeſs

confeſs I have found here a mining-ſchool, and from being a teacher am become a ſcholar." And ſoon after he ſays, "I could never have written any thing ſolid in chemiſtry, without having ſeen ſo much of Cornwall." This our German countryman made the moſt important improvements in working mines, and extracting metals in Cornwall: among other improvements, he firſt introduced there the machines for draining mines, and the uſe of pit-coals for the melting of minerals.

Since his time theſe mines have been only rarely viſited and deſcribed by foreign naturaliſts, ſo that the knowledge of the foſſils belonging to them is not yet ſo general as it merits. In the works of Engliſh authors, *e. g.* Woodward's Hiſtory of Foſſils, and Borlaſe's Hiſtory of Cornwall, the foſſils of Cornwall have been treated of, but not with ſufficient mineralogical, and with ſtill leſs chemical knowledge, which in the times of thoſe writers was every where defective. But, at preſent, as the Britiſh nation has began to produce in this department of ſcience alſo men of merit and activity, who advance with laudable ardour mineralogy and chemiſtry in their own country, we may expect important additions to both theſe branches of natural knowledge. In the mean time I will give as a ſketch, the following ſmall additions to the knowledge of ſome curious, and in ſome reſpect, little known foſſils of Cornwall, which I received from my worthy friend, John Hawkins, Eſq. with whom I had the pleaſure of making ſome of the following analyſes.

MINERALOGICAL OBSERVATIONS.

TIN ORES.

WHETHER true native tin has ever been found, as ſome mineralogiſts have aſſerted, is a queſtion not yet determined, even in Cornwall. On the contrary, it is rather thought that thoſe pieces of metallic tin, which have been found there, are only a production of art.

The common tin ores are in a calciform, and at the ſame time indurated glaſs-like ſtate, more or leſs mixed with calx of iron, and commonly joined alſo with ores of arſenic. *Zinſtein,* (Tin-ſtone,) might be the general denomination of them, but commonly only the irregular and compact ſpecies are called ſo. The cryſtallized tin-ſtones, on the contrary, are called *Zinngraupen*, if the cryſtals are diſtinct, and ſomewhat large; but *Zinnzwitter*, if the cryſtals are ſmaller, and not ſo diſtinct, reſembling ſmall grains, ſcattered through a compact raw tin-ſtone, or a ſtone of any other kind.

Theſe ſpecies of Corniſh tin-ores differ from thoſe of Bohemia and Saxony principally in this, that in general they contain leſs iron and leſs arſenic; and this is the cauſe of the preference the Engliſh tin in general obtains, on account of its purity.

The common matrix is Killas and Growan. A deſcription of both is to be found in Mr. Kirvan's mineralogy. Growan conſiſts of white clay, mixed with mica and quartz, and is of no peculiar texture: it is, therefore, nothing elſe but decayed granite, in which the Feldſpat has been broke down into clay.

Killas,

Killas, which might be juſtly called *Saxum metalliferum cornubienſe*, has been claſſed by Mr. Kirvan, under the hornſtones; he found 100 grains of the grey lamellar killas to contain about 60 of ſilex, 25 of argill, nine of magneſia, and ſix of iron. The greeniſh ſort contains more iron. Some of the cryſtallizations of the *Zinngraupen* from Cornwall are very remarkable. The moſt regular, but which are found only rarely, are quadrangular priſms, with double quadrangular pyramids: there are ſome alſo where the priſm is wanting, and both pyramids are joined together by their baſes, ſo that the cryſtal is octoedral. Such regular cryſtals are found at Trevaunance and Soil-hole, in the pariſh of St. Agnes. Similar quadrangular priſmatical cryſtals, very tender, and often only of the thickneſs of a hair, are found in tin-ſtone upon killas, at Polgooth, one of the richeſt tin mines, which at this time produces monthly a clear profit of from 1000 to 1200 pounds ſterling. The two cryſtallizations which have been mentioned are the baſes of all others, though theſe, by their extremities and angles being truncated, and by their being variouſly grown together, commonly appear very irregular. The fine poliſh moſt of theſe tin-cryſtals have gives them a peculiar beauty, which is often heightened by a certain degree of tranſparency. Such tranſparent cryſtals, in what is called Elvan, a ſpecies of argillaceous ſhiſte, are found at Kreegbraws in Kenwyn. The rays of light paſſing through gives them a bright brown-reddiſh gloſs, for which reaſon the miners in Cornwall call them Roſin-tin. Tin cryſtals of very gloſſy appearance, but on account of a larger proportion of iron, of a quite dark black colour, are found at Poldice.

Theſe ſpecies of tin-ores give a peculiarly good tin, becauſe they are the moſt free from arſenical pyrites. Among my ſpecimens there are only a few which are

mixed

mixed with arſenic and interſperſed through yellow copper ore; theſe are from Poldice. The tin ores from Huel Brea Load, in the pariſh of St. Ives, and from Cornellow Cliff, in Zennor, are united to ſhoerl. In thoſe from the former place the tin-ſtones are like a heap of cryſtals of different ſizes interwoven with a compact, finely radiated greeniſh grey ſhoerl neſtways in granite: But from the latter place I have ſpecimens of blackiſh *Zinnzwitter* in a vein only half an inch thick, the walls of which are a fine ſhoerl.

In another tin vein at Pelmine, in the pariſh of St. Agnes, the thickneſs of which is one inch and a quarter, both walls conſiſt of pretty large tin cryſtals of a light greyiſh yellow colour, by means of which the vein is very evenly ſeparated from the rock: the ſpaces between the tin cryſtals are filled up by a reddiſh white quartz.

Tin-

Tin-ſtone with wolfram is found at Wheal Mutterel, in Gwennap.

Zinngraupen, both of large and middle ſizes, in double quadrangular pyramids, ſo as to form what is called *Viſirgraupen*, the cryſtals of which have loſt ſomething of their gloſs and ſharpneſs of angles are found at Bun-mine, in St. Auſtle, in much decayed granite or growan. Other ſpecies of rich tin-ſtones and *Zinnzwitter* are found at Mainvroſe and Mengarn in Wendron, Trethallan in St. Stevens, and Huel Malkin. The tin-ſtone from the latter place is formed by very ſmall clear white grey tin cryſtals, grown intimately together, with very fine, moſtly greeniſh particles of mica. In ſome places the tin-ſtone has fiſſures, the cavities of which are lined with ſmall tin cryſtals, of a garnet form; now and then it is run through with ſmall veins of red jaſper, and contains nodules of it.

STREAM-

STREAM-TIN.

Not only the above-mentioned tin-ſtones, which are taken out of veins, produce metal, but likewiſe what are obtained from ſtream works, ſimilar to thoſe in Germany, yield a conſiderable quantity of rich tin ores. The manner of ſtreaming or collecting the tin rubbles, with which the valleys of the tin mountains in Cornwall are filled in great abundance, and to conſiderable depth, is briefly the following; the ſoil of ſuch valleys is dug ſeveral feet deep to the tin ſtratum, and, by water led over, waſhed of all the waſt. It is very probable that violent torrents of water have broke theſe tin rubbles from the original veins of the tin mountains, and rolled them down the declivities of hills into the lower grounds. Mr. Jars, indeed, believes theſe fragments to be remains of heaps of refuſe, from the ancient unſkilful working of the mines, which by inundations have been waſhed down

down from the mountains, and formed beds in the valleys.

This ſtream-tin is found of different ſize, colour, and figure, but moſt commonly rounded by water, and very like the common pebble, excepting in its very conſiderable weight.

The ſtream-tin collected at Ladock principally conſiſts of ſuch round, oval, ſomewhat ſmooth pieces, in general from the ſize of a bean to that of a pea, and leſs, whoſe poliſhed ſurfaces ſhew great variety of reddiſh grey, light brown, and dark yellow colours.

A ſimilar ſtream-tin from Penſagillis is remarkable on account of the native gold, which now and then is met with in it; and found, though very rare, in pieces of the value of two or three pounds ſterling. In my collection from this place is a grain of native gold, of the ſize of a flattened pea, with a cryſtallized ſurface. Probably in ancient times there were in theſe hills veins of gold, which have been broken down by violent inundations.

Stream-

Stream-tin in blackiſh rough grains is found at Perran Porth in Perranzabulo, where it lies ſome yards under the ſea-ſand, and therefore can be collected only at the time of low-water.

It is found at Hallibeſack in Wendron, Frogmoor in Probus, at Saint Denis and Roach in larger and leſs rounded pieces, many of them ſtill ſhewing their cryſtallized angles. The ſpecimens of ſtream-tin, from Swan-Pool in the pariſh of Ladock, are often mixed with pieces of cubic galena.

The moſt remarkable ſpecies of ſtream-tin is a tin-ore like haematites, or what is called Wood-tin. This tin-ore is only found within a ſmall circuit, in the three adjoining pariſhes of Saint Columb, Roach and Saint Denis, and is very ſcarce. The moſt favourable opportunity of getting it is at the time when the workmen, who ſtream the tin, bring to the melting-houſes the quantity of ore they have collected during three or four months;

amongſt

amongſt this we may ſeek for, and expect to meet with, wood-tin.

This rare tin-ore, which is entirely without the cryſtallized form proper to tin-ores, and on the contrary reſembles very much haematites, is not, as it at firſt appears, a true haematites, with which ſome tin is mixed, but a true and rich tin-ore, in which the portion of iron common to all tin-ores is only in an inconſiderable quantity, as will be ſeen plainly in the chemical analyſes to be mentioned afterwards.

Profeſſor Brunnich, of Copenhagen, is, as far as I know, the firſt who made this mineral known, and I ſhall copy therefore his words from a diſſertation inſerted in the Memoirs of the Royal Swediſh Academy of Sciences for the year 1778, under the title of *A Deſcription of two tin-ores from Cornwall.* "The other ſpecies is very rarely found, and is called in Cornwall Woodlike tin-ore. It has fine fibres, converging to different centres, like

like the radiated zeolyte, but it is ſo compact and hard, that it gives ſparks when ſtruck with ſteel. In mineral acids it is not conſiderably diſſolved. Broken in pieces it ſhews conical figures, and preſerves its fibrous appearance till it is powdered. The general colour is yellowiſh, with concentric lines of lighter and darker colours, and ſome quite black. I have not yet ſeen any one of this kind in its perfect form, but always in broken pieces, either of hollow ſpheres or of ſolid ones, having a blackiſh brown cruſt upon their external ſurface, which is ſmooth and ſpherical like ſome haematites: pieces which are poſſeſſed of this cruſt are very rare. Sometimes there is a little white quartz joined to them. They are never found in veins or fiſſures of any conſiderable depth in the ſolid rock, but only waſhed together in the valleys, which may be ſeen indeed by their rounded ſurfaces. The ſpecific gravity with reſpect to water at about 45 degrees of

heat,

heat, according to Fahrenheit, is as 580 : 100. It gives 34 parts of tin in 100; when roaſted it gives ſome ſign of arſenic; the yellow colour changes to a reddiſh; and when thus changed, a ſmall part is attractable by the magnet. I received this mineral from Mingums near Saint Columb, and from Saint Denis in Cornwall. I call it radiated yellow tin ore."

This deſcription of Mr. Brunnich is juſt, except with reſpect to the ſpecific gravity of the ore, and the quantity of tin contained in it. The firſt is, according to my hydroſtatical experiments with pure pieces, as 645 : 100; and the aſſay gives, by a proper management, 63½ parts of tin in 100. Mr. Brunnich mentions this wood-tin alſo in his Mineralogy among the tin-ores: but the radiated tin-ore of Wallerius, from Siberia, quoted by Mr. Brunnich, is, according to Mr. Romé de l'Iſle, not tin-ore, but wolfram.

In

In the *Elémens de Minèralogie* of Mr. Sage this Wood-tin is mentioned under the name of *Mine d'étain en ſtalactite*. Mr. Romé de l'Iſle deſcribes it according to Mr. Brunnich; and in his Mineralogical Tables, which he has annexed to his treatiſe of the external characteriſtic ſigns of minerals, he adds to the denomination of Mr. Sage *hêmatite d'étain*. Mr. Bergmann alſo ſpeaks of this mineral in his Doſimaſia viâ humidâ, in the following words: Nuper variationem in Anglia inventam obtinuimus peculiarem, quae ſtratis ſphaericis contiguis, radiiſque e centro prodeuntibus, haematiten fuſcum omnino refert.

The following deſcription, which was communicated to me in writing by Inſpector Werner of Freyberg, our maſter in minerography, cannot fail to be particularly agreeable to mineralogiſts.

Stannum ochraceum cornubiense

"The colour of it is hair-brown, ſometimes lighter, ſometimes darker; when lighter it approaches ſomewhat a yellow grey, and ſometimes an Iſabella yellow. Not unfrequently there are two or more ſhades of this colour in one piece in the ſmall parallel ſpherical ſtriae, which run acroſs it.

It has never been found but in ſmall pebble-like pieces, which are partly much rounded, and partly ſtill retain their former irregular augular figure, or the ſplittered form of their fragments, with angles only a little rounded. There are found, though but rarely, pieces which ſhew on one or more ſides their original ſmall ſpherical external protuberances.

The ſurface of theſe pieces is only a little rough.

The external ſurface of this foſſil has only a ſmall degree of luſtre, but internally it is ſomewhat brighter, and in general of a common luſtre.

It

It is very tender; the ſtructure is fibrous; the fibres are ſtraight, and commonly divergent from one ſide.

It breaks partly into regularly angular, partly into ſmall, ſplittered and wedge-like pieces. It is found moſtly in ſomewhat large and long angular and grain-like pieces, with a reſplendent ſurface: often alſo in diſtinct conchoidal pieces, the convexity of which is towards the ſurface, covered with the ſpherical protuberances; ſometimes it is found entire; when ſcratched, it ſhews a yellowiſh grey trace; it is hard, but may be cut with a file; its gravity is always conſiderable; ſometimes great, and ſometimes very great.

" The brown haematites is the only foſſil to which it bears a reſemblance; but there is a ſufficient difference with reſpect to external figure and to colour both in maſs, and when reduced to powder and, above all, with reſpect to hardneſs and weight, to enable us to

 diſtinguiſh

diſtinguiſh them: is it likewiſe diſtinguiſhed by a ſomewhat leſs internal gloſs, and by the greater tenderneſs of its fibres. *."

With this excellent deſcription of Mr. Werner may be compared the annexed drawings of the three principal ſpecimens of my collection, which could be more eaſily taken of this foſſil than of many others, on account of the apparent organical ſtructure, and want of metallic ſplendor.

The cryſtals of quartz, which interſect moſt ſpecimens of this ore, lead us to ſuſpect that the vein has been quartz; and this is rendered more probable by a piece I have, which has quartz upon both ſides of it.

* The above deſcription, though tranſlated with fidelity, may, perhaps, give the reader leſs ſatifaction than he would expect from Mr. Klaproth's character of it: this, in ſome meaſure, is owing to the want of an Engliſh technical language correſpondent to the German one; and, perhaps, in a greater meaſure to Mr. Werner's attempting to diſtinguiſh nicely degrees of qualities which do not admit of meaſurement.

As

As a kind of Wood-tin, I am inclined to confider another ftill more rare fpecies, called Shot-tin, which is brought from Maddern. This is only found in fmall feparate hemifpheres of the fize of a divided fhot. The furface is fmooth, and brown, but the infide, or the nucleus, is of a light-brown, and of white yellow colour, and flightly radiated. Thefe ftalactitical hemifpheres, which, as one may fee, have been fixed to other bodies, are fimilar to the fmall fpherical protuberances of Wood-tin, excepting that the latter are not fo hemifpherical, but flatter.

Sulphurated tin-ore from Cornwall.

At Huel Rock in Saint Agnes, there has been found a metallic vein, nine feet wide, and twenty yards beneath the furface. The conftituent parts of this ore, although experiments had been made upon it, were ftill unknown. Mr. Rafpe, who now lives in Cornwall, is the firft who difcovered this unknown ore to be Sulphurated tin.

The firſt, and, until now, the only inſtance of a native ſulphurated tin, is mentioned by Mr. Bergmann. He received it under the name of antimony from Siberia, and the ſpecimen was only of the ſize of a hazle-nut. As ſulphurated tin-ores then are ſo very ſcarce, an account of the exiſtence of a large vein in Cornwall cannot fail to be agreeable to mineralogiſts.

My ſpecimens conſiſt of the compact ore, only here and there are marks of growan, which is the matrix of it. The colour of this ore is, in general, a blueiſh white, approaching a ſteel-grey, and comes near the colour of grey copper ore. Its coheſion is in ſeveral places interrupted by cracks, often ſcarcely perceptible, filled with a very thin layer of yellowiſh and greeniſh clayey earth : from this cauſe the external texture ſeems lamellar, but the freſh fracture is generally irregularly angular. The metallic

ſplendor

ſplendor alternates in ſome ſpecimens with dull grey and blackiſh ſpots. It is not conſiderably hard, but very brittle. The ſpecific gravity varies according to the quantity of metal it contains: thoſe pieces which are more pure and white, and which are the richeſt of tin, are as 435 : 100. Excepting copper-pyrites, which is interſperſed in ſmall particles through it, no foreign body is mixed.

As I am not acquainted with the experiments of Mr. Raſpe, by which he thought himſelf intitled to declare it ſulphurated tin-ore, I will communicate in the following pages the analyſis I have made, which ſhew it to conſiſt of ſulphur, tin, copper, and ſome iron. The mixture is ſo exact and intimate, that the way of powdering and waſhing, which otherwiſe is very proper in tin-ores, is of no uſe. Mr. Raſpe propoſes to name this ore *bell-metal ore*; which denomination would be more juſt if there were a larger proportion of copper to the tin.

COPPER-ORES.

Cornwall is not only poſſeſſed of rich tin-mines, but alſo of very rich copper-mines, which produce copper ores of various forms, ſpecies and varieties.

Native copper is found in very conſiderable quantity at Cape Lizard, between the rocks near the ſea-ſhore in filiform branches, and veins of ſome thickneſs, contained in blackiſh ſerpentine, mixed with browniſh red, and covered externally with a greeniſh nephrites, partly adherent to it, partly looſe upon it. In the ſame rocks alſo native copper in large lumps has been found.

Huel Virgin produces in a conſiderable quantity native copper, which ſhoots into branches of various directions, which ſeem to be formed of ſmall rhomboidal cryſtals, interſperſed with quartz cryſtals, of which often only the impreſſions are to be ſeen in the native copper of the two ſpecimens I have from this place; one weighs

weighs three quarters, the other one pound and a half; but there has been found native copper in lumps of from twenty to thirty pounds in weight. How rich the mines of Huel Virgin are, may be perceived in general from this, that only in the month of March, 1785, they produced 1400 tons of rich copper-ore; each ton containing twenty hundred weight.

I possess from the same place, as also from Carrarach, which is contiguous to Huel Virgin, and which is no less rich, a specimen of crystallized native copper, with transparent vitreous copper ore, of a ruby colour, crystallized in octoedres: but this fine red crystallized vitreous copper ore begins to be scarce.

Near to the copper vein at Carrarach is found compact native copper, of a spherical form, in lumps, which either is still metallic, or is beginning to be transformed into red copper-glass, imbedded in decayed granite.

Native

Native copper, of a tender and moſs-like form, united to ruby vitreous copper-ore, cryſtallized in rhombs, is found in the clefts of mountains, compoſed of Killas, at Poldory. Very ſmall particles of native copper are interſperſed through Goſſan at Kaſtle Adit.

On ſome parts of the native copper-ores from Poldory and Huel Virgin, is found calciform - copper - ore, ſometimes only in a looſe form, and covering them like ſand, ſometimes of a compact ſtructure, and adhering ſtrongly to them. The former kind is generally black, the latter of a browniſh red, often approaching to the metallic ſplendor of copper. One may generally obſerve in theſe ores from Cornwall various gradations, calciform copper-ores, vitreous copper-ores and native copper: but I do not pretend to aſſert whether the metal is reducing or calcining.

Of ſulphurated copper ores, Cornwall has an abundance of various kinds.

Whitiſh

Whitiſh grey copper ore, cryſtallized in ſmall triangular and quadrangular pyramids, whoſe points are generally truncated, is found along with ſolid grey copper ore at Poldice and Dol-coth. But the richeſt copper ores are the ſolid grey from Treſeavean, Retal-lack, Cook-kitchen, Carrarach, Huel Virgin, Redruth. Some of theſe may be cut with a knife like ſoft vitreous ſilver ore, particularly thoſe from Tre-ſeavean; the analyſis of theſe laſt is given under No. 3.

Yellow copper ores are found at Pol-dice, Hallamanning, Dol-coth. From the latter mine, which is 160 yards deep, and yet elevated 60 yards above the level of the ſea, the moſt remark-able is a ſtalactitical ore, of an hemiſ-pherical form (Run-yellow copper) which is often variegated with the colours of blue ſteel or red copper. Calciform copper ores of great variety are likewiſe found in Cornwall. The rare cryſtal-lized

lized red vitreous copper ore has been mentioned before. Compact red vitreous copper ore, covered with green copper, or mountain green, as likewife with calciform copper, of a vermillion red, is found in cryftalized quartz, with tender green mica, at Kaftle Adit.

Compact green copper ore, like malachite, mixed with grey copper ore; likewife green velvet-like copper, grown in bunches, is found at Huel Virgin. Green copper ore, of no regular texture, is found in decayed granite at Carrarach; likewife ftratified betwixt cryftals of quartz, which at the fame time are covered with a brownifh red, foft, glittering iron-rham, at St. Meuan. Azur copper ore, in quartz, is met with at Huel Virgin and Carrarach.

This mountain of granite at Carrarach, fo rich in all kind of copper ores, (for the field-fpat having been decayed, and converted into clay, the quartz is rendered more capable of receiving metallic

fubftances)

ſubſtances) produces ſometimes alſo the two following cryſtallizations, the nature of which was till now unknown.

The firſt of theſe (which lines the cavities of a cryſtallized crumbled quartz, partly uncovered, and partly coated with indurated green copper, and alſo with dark brown velvet-like iron ochre) conſiſts of tender, olive-green coloured ſpiculae; theſe are about two or three lines long, and ſtand ſtraight up either ſingle or faſciculated and radiated. They conſiſt of copper mineralized by the acid of arſenic. When I tried them with the blowpipe, they deflagrated with arſenical ſmoke, and then fuſed, forming a button of a grey colour, which when melted again with borax, gave inſtantly a button of very pure copper.

The other cryſtals in my ſpecimen, are very ſmall, aggregated dark green cubes with ſmooth and ſhining ſurfaces upon grey copper ore in a maſs of cryſtallized compact quartz with cavities in it.

it. They might be eaſily taken for ſmall cubes of fluor, but their conſtituent parts are copper and arſenic. Examined with the blowpipe, they ſwell in little bubbles, and emit the ſmoke of arſenic, but not ſo much as the firſt mentioned cryſtals, nor do they run ſo quickly into a grey metallic button. After this button had been melted with borax, it could be beat out upon the anvil into thin plates; but it was harder and ſomewhat more pale than pure copper, and had ſome ſpots of a ſteel colour. It would ſeem therefore that iron is mixed with it.

Beſides the tin and copper in which the principal richneſs of Cornwall conſiſts, it produces alſo other remarkable foſſils.

Galena in large cubes is found at Treſeavean with copper pyrites: at Poldice mixed at the ſame time with cuprous and arſenical pyrites in quartz and killas: and at Penroſe there is a rich vein of it which opens upon the ſurface.

Grey cobalt ore, either without or with Bifmuth, is found at Dol-coth. The chemical analyfis of the firft kind, which refembles very much in colour, fracture and other external appearances, the cobalt from Rappold at Schneeberg, which is ufed in manufactures will be given No. 4.

Cryftallized pfeudo-galena, or black-jack, mixed with pyrites, is found at St. Agnes. Pyrites or Mundick are to be met with very frequently in different forms: large cubes of pyrites imbedded in granite are found at Wendron.

Penzilly in Breage parifh affords haematites of a liver-brown colour mixed with manganefe. This foffil, which was fent from Cornwall by the name of liver-coloured Tungften, is found in a vein of a yellow friable iron-ochre, through which this fuppofed Tungften runs in veins of different thicknefs and pofition. It is of a liver colour, even fracture, and fomewhat fibrous texure. The experi-

ments

ments related under No. 5, will be a ſufficient proof, that this mineral is not Tungſten, but manganeſe mixed with much iron.

Wolfram of a foliated texture united to quartz and white clay, is brought from Poldice. See experiments made upon it under No. 6.

The Aſphaltum, or indurated Bitumen, from Carrarach, is remarkable for being found 90 yards deep in granite.

Of the different kind of ſtones and earths of Cornwall, beſides the above mentioned killas and growan, the following are worthy of notice.

Chalcedony from Trevaſcus. It is found in fine, ſtalactitical, variouſly configured pieces formed of thin layers, and is now ſeldom to be met with.

Steatites or ſoap rock is found running through ſerpentine in ſmall ſhallow veins at Cape Lizard. The fineſt ſpecies of it is white, ſtreaked with veins of a blueiſh and reddiſh colour. It is ſo ſoft as to be

ſcraped

ſcraped by a knife like ſoap; but in the fire it acquires a conſiderable degree of hardneſs. It is made uſe of in the manufacture of porcelain, and for this purpoſe is collected by the managers of the Porcelain manufactory at Worceſter, who pay 20 pounds ſterling for a tun of twenty hundred weight, becauſe the digging of it, on account of the great brittleneſs of the ſerpentine rock, is very dangerous. The analyſis of this ſpecies is given No. 7.

There is alſo found a leſs fine ſort with ſpots of iron ochre, and likewiſe a variety of a reddiſh brown colour, mixed with green. That of Ruan minor is of a greyiſh white, and light ſlate blue colour. There is found alſo a whitiſh ſteatites grown through with calcareous ſpar, which gives to the former a ſmooth ſhining fracture.

White Porcelain earth: this is produced by the decompoſed feldſpat of a decayed granite which fills the valleys in Corn-

 wall,

wall, and is ſeparated by waſhing. That from St. Stephens is principally uſed for porcelain: of the other leſs pure ſorts very good crucibles are made.

Talc and aſbeſtos are found in the ſerpentine rock near Cape Lizard.

Mica of a grey colour and lamellar texture is to be met with at St. Dennis; and Black Bar-Shoerl imbedded in granite is found at Logan Rock near the Lands-end.

This ſhort mineralogical view of my collection of Corniſh foſſils, muſt not be, as I have already mentioned, conſidered as complete, many additions being neceſſary to it.

I ſhall now proceed to give an account of ſome chemical analyſes, which I have made of them.

CHEMICAL

CHEMICAL EXPERIMENTS.

WOOD-TIN.

§ 1.

THE obftinacy to folvents which diftinguifhes tin ores in general when examined in the liquid way, I have found in a great degree in the Wood-tin.

(a) The fimple acids had very little effect. Aqua regia made a perceptible folution: 60 grains of Wood-tin reduced to the moft fubtile powder, and digefted in 3 ounces of it in a ftrong heat long continued, loft only 5 grains. I tried therefore the method recommended by Mr. Bergmann.

(b) Upon two drams of finely powdered wood-tin, I poured one ounce of concentrated acid of vitriol, and digefted it for

ſome time in a boiling heat; afterwards I added cautiouſly two ounces of concentrated marine acid, digeſted it again, and diluted it with water: when the ſolution was clear, I poured it off from the reſiduum depoſited at the bottom. I repeated this proceſs twice with the reſiduum, each time with half the quantity of the acids. The undiſſolved reſiduum weighed 98 grains, and retained its appearance. The ſolutions poured together had a ſomewhat gold yellow colour: ſome of it examined with phlogiſticated alkali, diſcovered iron by its blue colour. The reſt of the ſolutions being ſaturated with vegetable alkali gave a precipitate of a dirty white colour, which weighed when dry 27 grains. This precipitate examined with the blow-pipe, ſhewed a tendency to melt and form a metallic globule, but this was again inſtantly calcined. Melted with microcoſmic ſalt, a greyiſh white porcelain-like ſcoria was formed: with borax it would not unite, but remained diffuſed diffufed through the borax glafs. Upon the remaining precipitate marine acid was poured, which foon diffolved it; from this folution, after having been diluted with water, tin leaves were depofited upon a cylinder of zinc.

(c) In order to know, if wood-tin could be made to diffolve more eafily in acids by melting it firft with alkali, one dram of it was melted with three drams of fixed vegetable alkali, and the light brick-coloured mafs, which was produced wafhed in water, and the folution filtred. The ley which paffed clear through the filtre was not changed in its appearance by acids; and the edulcorated and dried powder, which was lefs coherent, and of a redder colour, was not more foluble than before.

(d) One dram of pulverized wood-tin was mixed with three drams of fal ammoniac and fublimed in a fmall matrafs. The fublimate was of a greyifh yellow colour. The refiduum was again fublimed

with three drams of ſal ammoniac, which was coloured like the firſt. The remaining wood-tin had loſt only a few grains in weight. A ſolution of the ſublimate in water was tinged blue by the phlogiſticated alkali; the fixed alkali precipitated a little light grey not coherent powder, which appeared an impure calx of tin.

§ 2.

Theſe experiments indeed ſhew this foſſil to be a calx of tin, united with a ſmall portion of iron, ſimilar to the common tin-ſtones: but to know the quantity of metal contained to it, a reduction was neceſſary. And as in aſſaying tin ores the produce depends very much upon circumſtances, the reduction of this ore was tried under the following variations;

(a) Wood-tin, 1 dram.
White glaſs, 2 drams.
Calcined borax, 1 dram.
Powdered charcoal, 10 grains.

This

This mixed and melted in a ſtrong fire during an hour, in a crucible lined with charcoal, and to which a cover was luted, (as has been done in all the following experiments,) gave a dirty olive coloured ſcoria, in which the reduced globules of tin lay diſperſed; theſe were collected by powdering and waſhing, and weighed 10 grains and a half.

(b) As I had often found the ſal ſedativum to be a remarkably good flux for reducing metals, I tried it in this inſtance, and mixed

Wood-tin, 1 dram.
Sal ſedativum, 3 drams.
Powdered charcoal, 10 grains.

This mixture, melted likewiſe during an hour, gave a blackiſh lamellar porous ſcoria, mixed with charcoal: the tin globules contained in it, ſeparated by powdering and waſhing, weighed 19 grains.

(c) I was led to ſuppoſe an hour to be too long for keeping it in a melting ſtate,

becauſe a part of the reduced tin was again calcined, and mixed with the ſcoria; for this reaſon I repeated the laſt experiment, but with this difference, that I kept the mixture only half an hour in the fire, and the reſult ſhewed, that I had approached the proper time; for now I obtained $30\frac{1}{2}$ grains of pure ſilver-coloured tin globules, upon which the loadſtone had no effect.

(d) Under the ſame circumſtances I made two other aſſays, one with the tin ore from Schlackenwalde in Bohemia, and the other with the pure cryſtallized tin-ſtone from Mengarn in Cornwall. The powdered tin ore from Shclackenwalde gave 16 grains of globules of tin of an iron-grey colour, and very attractable by the magnet.

e Afterwards I tried the reduction only by the addition of phlogiſton without any flux. I mixed 1 dram of wood-tin with an equal weight of colophony in a crucible covered with powdered charcoal, and let it remain half an hour in a melt-

ing

ing heat. I found at the bottom of the crucible an uniformly melted regulus of tin, the weight of which was 26 grains, and I collected, by washing the powdered charcoal, 11 grains more in small globules, and half a grain of black flocculi very attractable by the magnet. The inner surface of the cover was sprinkled with small globular particles of tin, which could not be collected, but which I thought equivalent to 1 grain.

The reduction by phlogiston alone is therefore the best, and proves wood-tin to be one of the richest tin-ores, for there are very few other tin-ores, which assayed give $63\frac{1}{3}$ in 100.

§ 3.

This tin seemed to be nevertheless somewhat more brittle and hard than pure tin. When dissolved in marine acid a residuum was left of blackish, shining scales, three-

three-fourths of a grain in weight. Of this examined with the blow-pipe a part rose in arsenical smoke, and left one-eighth of a grain of iron attractable by the magnet. To half of the solution in marine acid was added phlogistated alkali; by which the calx of tin was precipitated of a white colour with some spots of blue. From the other half, saturated with volatile caustic alkali, the tin was precipitated likewise in form of white calx: after standing for some time a small cloud of yellow calx of iron hung over it.

SULPHURATED TIN-ORE.

In those pieces I have examined, which were indeed of the same vein, but taken from different parts of it, I found, according to the difference of colour and splendor, the proportion of the component parts something different, so that the surest way of ascertaining the true proportion

proportion is to take the mean reſult of many experiments.

§ 1.

Half an ounce of this tin-ore was heated red hot in a ſmall glaſs retort. When cold, about two drops of a fluid, which proved to be volatile ſulphureous acid, were found in the receiver. In the neck of the retort was a little grey yellow ſublimate, about one-fourth of a grain. This ſublimate carefully collected and placed upon a red hot charcoal, ſmelled and burned at firſt like ſulphur, but afterwards a ſmell of arſenic was perceived. The reſiduum had loſt 3 grains.

§ 2.

Two drams of this ore were ſlowly heated in an earthen veſſel, till no ſmell of of ſulphur could be perceived. It was changed by it into a red calx, and weighed 2 drams, 20 grains, though it had loſt its portion of ſulphur, which is conſiderable. This calx mixed with an equal weight of calcined borax, half its weight of white glaſs, and a fourth part of colophony, and melted in a ſtrong heat, during half an hour in a crucible lined with charcoal, and covered with common ſalt, gave a ſmall regulus of a grey colour, 10 grains in weight, but which was ſo brittle that it flew in pieces when gently ſtruck with a hammer. The reſt of what was reduced was in very ſmall globules, which lay ſcattered in the powdery ſcoria mixed with charcoal.

The reſult of this experiment proves, that the common dry way of trying this ore is totally improper.

§ 3.

§ 3.

(a) Upon half an ounce of tin ore finely powdered was poured 4 ounces of aqua regia, compofed of two parts of marine and one part of nitrous acid. The metallic part was moftly diffolved in 24 hours without heat, and the fulphur rofe to the furface. After the folution was digefted again in a fand bath for two hours, it was diluted with water and filtred. There remained two grains of fandlike earth: the feparated fulphur weighed 75 grains. But the fulphur wanting a pure yellow colour, appeared ftill to contain fome metallic parts: it was flowly deflagrated, and left 17 grains of a black grey refiduum.

(b) To the filtred metallic folution I added fixed vegetable alkali. But obferving the firft precipitate, which had a whitifh colour approaching to yellow, to be

be different from the next, which was of a greeniſh colour, I deſiſted as ſoon as the precipitate began to ſhew this greeniſh colour. I collected the whitiſh precipitate by a filtre, edulcorated and dried it; having diſſolved it again in marine acid, I put into this ſolution a cylinder of zinc. The tin precipitated itſelf on the zinc in a metallic ſtate, but was mixed with a portion of copper. This metallic precipitate was therefore diſſolved again in marine acid, by which means the copper remained undiſſolved, and the filtred ſolution containing the tin was now clear and colourleſs. Having put a cylinder of zinc into it, the tin was immediately precipitated in metallic ſhining flocculi, which when waſhed and dried weighed 48 grains, and when melted in a ſmall crucible covered with charcoal formed globules.

(*c*) The ſecond half of the metallic ſolution, which remained after the ſeparation of the firſt precipitate, was completely

pletely ſaturated with fixed vegetable alkali, whereby I obtained the remaining portion of copper in a precipitate of a pure green colour. Being edulcorated and dried, it was with thoſe 17 grains of metallic particles which were left after deflagration of the ſulphur, and with the copper which remained by depurating the tin (in the former experiment) ſtrongly heated and then digeſted in nitrous acid. After a ſtrong digeſtion, the blue ſolution of copper was ſeparated by the filtre from the inſoluble reſiduum, and the copper was precipitated by a poliſhed iron, and weighed 53 grains.

(d) The inſoluble reſiduum which was of a white grey colour, and weighed twenty-three grains, was heated in a crucible with a little wax: the magnet attracted three grains. The other 20 grains appeared to be calx of tin, which are nearly equivalent to 16 grains of tin in its metallic form.

The

The reſult of this analyſis is conſequently

Pure ſulphur	— —	58 grains.
—— Tin	— —	64
—— Copper	— —	53
Calx of iron	— —	3
Earth of the ſtony matrix		2
		180

But as there were ſtill 60 grains wanting, I choſe the following way, which gave me a much more juſt reſult.

§ 4.

(a) Two drams of the ſame mineral finely powdered was diſſolved in 1 $\frac{1}{2}$ ounce of the above mentioned aqua-regia. There remained undiſſolved 43 grains of ſulphur, which during digeſtion had formed itſelf into one maſs; ſome greeniſh ſpots ſhewed that a portion of metal was contained in it. After a gentle deflagration of it in an earthen veſſel, there remained 13 grains,

8 grains

8 grains of which were diſſolved in aqua regia, and added to the firſt ſolution. The inſoluble 5 grains were ſeparated by the filtre, and heated along with ſome wax: the magnet now attracted about 1 grain. The remainder weighed 3 grains, and conſiſted of argil and ſilex.

(b) To the ſolution of the metallic part was added fixed vegetable alkali: the precipitate was of a greyiſh green colour, and after having been edulcorated and dried, was diſſolved again in marine acid, diluted with 2 parts of water, and a cylinder made of pure tin, which weighed 217 grains, was put into the ſolution. The copper contained in the ſolution was precipitated in a metallic ſtate. The ſolution began to loſe its green colour from below, till at laſt all the copper being precipitated, it appeared without any colour.

(c) The copper weighed 44 grains. In order to try the purity of it, it was digeſted with heat in nitrous acid. The

ſolution was of a blue colour, and one grain of tin in a white calciform ſtate, was left undiſſolved. It contained therefore 43 grains of copper.

(d) The cylinder of tin uſed for precipitating the copper weighed now 128 grains, and 89 grains had been of courſe diſſolved. By a cylinder made of zinc I now precipitated all the tin, which was connected looſely to the zinc in tender leaves and arboreſcent forms. Being ſatisfied that all the tin was precipitated, I collected it carefully, waſhed and dried it. It weighed 130 grains. I then melted it, mixed with tallow and powdered charcoal, and when it was cold, ſeparated the charcoal by waſhing. With the waſhed tin globules I found ſome black flocculi of iron, attractable by the magnet, which weighed 1 grain. This being deducted from the weight of tin, there remained 129 grains. The above 89 grains of the cylinder of tin, uſed for precipitating the copper, taken then from this

ſum,

ſum, there remained 40 grains; to which muſt be added 1 grain of tin ſeparated from the ſolution of copper. The product of pure tin in this experiment is conſequently 41 grains.

The reſults of this proceſs are

Pure Sulphur	—	30 grains.
—— Tin	—	41
—— Copper	—	43
—— Iron	—	2
Earth of the ſtony matrix		3
		119

Of the two drams therefore uſed for this analyſis only one ſingle grain was loſt.

The reaſon why I firſt precipitated from the ſolution in aqua-regia with alkali, and diſſolved the precipitate again in marine acid, was in conſequence of knowing, that, when tin is precipitated from aqua regia by zinc, the whole quantity is ſeldom precipitated in a metallic form; but a conſiderable part of it is corroded by the nitrous acid, whereby the ſolution acquires a turbid opal-like appearance, and a jelly-like conſiſtence, which diſagreeable circumſtance cannot well be corrected. But if a turbidneſs appears in precipitating the tin by zinc from the marine acid, it is very ſoon removed by adding ſome drops of marine acid.

§ 5.

By repeated experiments according to this method I have found that in ſimilar pieces of this ore there is no conſiderable difference with reſpect to the proportion of its conſtituent parts. But in pieces of a different appearance, the break of which is of a darker colour, and without luſtre, I found a more conſiderable portion of iron.

I diſſolved half an ounce of this ore in aqua regia, and two different precipitates were

were made in the manner mentioned in § 2. The firft of a white colour, confifting of tin, was ftrongly heated in an earthen veffel, by which a fmell of arfenic was perceived. The whitifh colour of calx of tin was changed into a flefh colour, which it generally acquires by being long heated. After fome wax was deflagrated with it, it weighed 61 grains, and fcarcely one grain was attracted by the magnet. The fecond precipitate of a greenifh colour was likewife ftrongly heated, and became by this means a black heavy powder. Digefted with nitrous acid in a boiling heat the folution became blue. A light brown calx of iron remained, which dried and heated with wax weighed 18 grains, totally attractable by the magnet.

The quantity of iron contained in half an ounce of this ore was 19 grains in a ftate of phlogifticated calx; fo that in the former fpecies there was found a much lefs portion of iron.

§ 6.

Though in the courſe of theſe experiments no ſign of ſilver or lead was diſcovered, I made, in order to be quite certain, the following trial.

Upon the calcined tin ore, § 1. was poured nitrous acid, which acted with violence, emitting frequent red vapors. Being ſufficiently digeſted, water was added, and the reſiduum, conſiſting of ſulphur, and calx of tin, ſeparated by the filtre. The clear blue ſolution was treated with marine and vitriolic acid, and alſo with ſome neutral ſalts containing theſe acids, without being in the leaſt altered, a proof that no ſilver or lead was mixed.

§ 7.

The ſolubility of the tin contained in this mineral in aqua regia and marine acid, which is not the caſe with that of the common calciform tin ores, or with any ſtrongly dephlogiſticated tin calx, is a ſufficient proof, that the tin is in this caſe united to the ſulphur, in ſuch a ſtate as to approach metallic tin. I think this in general to be the caſe with all other mineralizations. The following experiment is ſtill more convincing.

(*a*) Half an ounce of ſulphurated tin ore, mixed with the ſame quantity of corroſive ſublimate, was put into a ſmall retort, a receiver was applied, and the retort placed in a ſand bath. When moderately heated, a heavy fluid with white heavy vapors came over, and by increaſing the heat, a ſublimate of a grey yellow colour, moſtly cryſtallized in needles, was formed in the neck of the retort, and an impure dark grey cinnabar was found adhering to the upper part of the retort, beneath the neck.

(b) The fluid collected in the receiver weighed one dram, and was ſimilar in all reſpects to the butyrum ſtanni fumans Libavii. One drop of it added to a diluted ſolution of gold, precipitated a purple powder. The above fluid was diluted with water, and the tin precipitated by fixed vegetable alkali. This very looſe white precipitate, waſhed, and dried, weighed 30 grains.

(c) The ſublimate collected from the neck of the retort *(a)*, was triturated and digeſted with water, and filtred: the reſiduum weighed, after having been dried, 203 grains. Theſe were diſſolved again in aqua regia, excepting a reſiduum of 15 grains of ſulphur: from this ſolution the mercury was precipitated in a metallic form by copper. The ſolution in water was precipitated by

fixed

fixed vegetable alkali: the precipitate weighed ſixteen grains, and reſembled the precipitate of tin, mentioned *(b)*, and was added to it.

(d) This calx of tin was diſſolved again in marine acid, and precipitated from it in a metallic form by a cylinder of zinc. The metallic precipitate, collected, waſhed, and melted in a ſmall crucible, with ſome tallow, gave a button which weighed twenty grains. After having been flattened, and cut in pieces, it was digeſted in nitrous acid, and when completely calcined, diluted with water, and filtred. The ſolution was then examined with phlogiſticated alkali, and ſome brown flocculi were precipitated; a mark of the tin being ſtill mixed with a ſmall portion of iron.

(e) In order to render theſe experiments more ſatisfactory, ſimilar ones were made with a pure kind of *zinzwitter*: but in theſe there was not the leaſt mark of the butyrum ſtanni, and the corroſive ſublimate,

ſublimate, mixed with the *zinzwitter*, was ſublimed, unaltered, in needle-like cryſtals; the remaining tin-ore was alſo not changed.

§ 9.

The moſt accurate method of analyſing this mineral, is that deſcribed in § 4. according to which, by repeated experiments, the ſulphurated tin-ore from Cornwall, of the pure light coloured kind, was found to contain in a hundred,

Sulphur, — —	25
Tin, — —	34
Copper, — —	36
Iron, — —	3
Earth of the ſtony matrix,	2
	100

The proportions in the darker varieties of this ore, are ſomewhat different,

ferent, as they contain about eight parts of iron in a hundred. The very trifling mark of arſenic obſerved in § 1. deſerves no notice.

Grey Copper Ore from Treſeaven.

I only mention theſe experiments as a proof that the moiſt way of aſſaying ores is in ſome caſes preferable to the common ſmelting proceſs. Copper-ores eſpecially, aſſayed in the dry way, do not give the exact quantity of metal contained in them. This is partly owing to a tendency the calces of copper have to form in a ſtrong heat ſcoriae, and partly to a diſſolution of a portion of the copper by the alkaline fluxes which are uſually employed.

The fluxes conſiſting of glaſs, borax, and charcoal, recommended by Meſſrs. Gellert, Tillet, de Morveau, and other metallurgiſts, give, indeed, more regulus of of copper than the common alkaline fluxes: but the analyſis of copper ores in the moiſt way, according to the following experiments, is ſtill the moſt accurate.

(a) Half an ounce of this copper ore, pulverized, and properly calcined, loſt 14 grains. It was then mixed with an equal weight of calcined borax, half its weight of white pounded glaſs, and 1-4th of roſin; and after all, being gradually heated in a crucible lined with charcoal, covered with common ſalt, was melted in a ſtrong heat during half an hour. Under an uniformly fuſed blackiſh grey ſcoria was found a globule of copper, which weighed 71 grains, which is $29\frac{7}{12}$ in 100.

(b) Upon half an ounce of the ſame copper ore, calcined, was poured two ounces of ſtrong concentrated acid of vitriol. The mixture was diſtilled to dryneſs: what remained was waſhed with water, the ſolution filtred, and the cop-

per

per precipitated by a poliſhed iron. The quantity of copper now obtained was 135 grains, or 56¼ in 100. Theſe 135 grains melted with the above-mentioned flux, gave a globule of copper which weighed 133 grains.

Grey Cobalt Ore from Dol-côth.

§ 1.

(a) Half an ounce of this cobalt-ore reduced to a ſubtile powder, was gradually diſſolved in aqua regia, made of equal parts of nitrous and marine acid. The ſolution was briſkly performed, very frequent red vapors being expelled, and only a grey muddy reſiduum, 1½ grain in weight was left; this deflagrated upon charcoal with a flame, and ſmelled at firſt like ſulphur, but afterwards like arſenic: ſome earth remained.

(b) The

(b) The filtred ſolution, of a browniſh colour, was only imperfectly ſaturated with fixed vegetable alkali. The precipitate of a whitiſh, approaching to a yellow-ochre colour, was ſeparated by the filtre, and weighed when dry five drams fifteen grains. It contained iron and arſenic: mixed with powdered charcoal, and heated, the arſenic ſublimed in thick vapors, and left the iron.

(c) This ſolution, the arſenic and iron having been ſeparated, was of a pale red colour, and was now completely ſaturated by the fixed vegetable alkali. The precipitated calx of cobalt was of a reddiſh grey colour, and weighed when edulcorated and dried one dram fifteen grains.

§. 2.

(a) One ounce of finely pulverized cobalt-ore was calcined in an earthen veſſel

veſſel in a ſtrong heat, till no ſmell of arſenic could be perceived. This calx of cobalt was of a dark brown colour, and had loſt exactly the third part of its former weight. It was melted in a crucible, with a mixture of two ounces of black flux, and one dram of roſin, and covered with common ſalt. A compact regulus of cobalt was obtained, which weighed $158\frac{1}{2}$ grains, after a ſmall portion of $3\frac{1}{2}$ grains of biſmuth was ſeparated. The fracture of this regulus of cobalt was of a fine granular texture, interwoven with ſome tender ſtriae, like a net. Small pieces were attractable by the magnet, but upon larger ones, ſome grains in weight, the magnet had no effect.

(b) The pulverized regulus of cobalt was put by ſmall portions into nitrous acid, which diſſolved it very briſkly; the ſolution was then digeſted for ſome time, diluted with water, and ſeparated by the filtre from the inſoluble light yellow calx of iron. It was of a brown

red

red colour, and afforded a green ſympathetic ink, by adding ſome portion of common ſalt; a proof that it contained ſtill much iron. After having diluted it with water, I added ſlowly fixed vegetable alkali in ſolution, and took care to ſtop when the precipitate began to change its colour from that of a muddy calx of iron to a violet, and the ſolution had obtained a clear roſe colour. This ſolution freed from all precipitate of iron by the filtre, and employed as a ſympathetic ink, gave a beautiful ſky-blue. It was now completely ſaturated with alkali, and the pure calx of cobalt was precipitated of a violet colour, and when edulcorated, dried, and finely levigated, weighed 70 grains. Two grains of it mixed with one ounce of glaſs frit, gave, when properly melted, a very fine ſapphire blue glaſs.

(c) The iron which had been united with the regulus of cobalt, and which was precipitated from the ſolution in nitrous

nitrous acid, in part ſpontaneouſly, and in part by alkali, was edulcorated, dried, and made red hot along with ſome fat. It weighed 156 grains, and was totally attractable by the magnet. By other experiments I have found the proportion of the calx of iron, made attractable by heating it, to the iron in a metallic ſtate to be as 7 to 5. As, therefore, thoſe 156 grains of phlogiſticated calx of iron are equivalent to 111$\frac{1}{2}$ grains in a metallic ſtate, the quantity of pure cobalt metal free from iron obtained from one ounce of this cobalt ore, the regulus of which weighed 158$\frac{1}{2}$ grains, muſt be 47 grains.

(d) I obſerved in the following experiments a remarkable difference between the violet calx of cobalt obtained from the regulus, and that from the cobalt ore (§ 1. *c*). A ſmall quantity of the firſt, diſſolved in ſmoking marine acid, gave a beautiful ſapphire blue colour

I had never before feen in a folution of cobalt. The other precipitate of cobalt, prepared from the ore in folution, with the fame acid, gave, on the contrary, a dark grafs-green colour.

The caufe of thefe appearances feemed to be the fmoking principle of the marine acid. For as foon as the folution was diluted with water, the colours of both difappeared, and changed to a light rofe red. With marine acid, which was not fo concentrated as to fmoke, the folutions obtained immediately a red colour, as if vitriolic or nitrous acid had been ufed.

§ 3.

From the external appearance, as well as from the analyfis, I imagined this cobalt from Cornwall, might give, like thofe employed in Saxony, a very fine fmalt. The refult of experiments made

made in different proportions, confirmed this opinion.

(*a*) Calcined cobalt, 1 dram,
Sand from Freyenwalde, prepared,
Fixed vegetable alkali, of each 3 drams.

Theſe well mixed, and kept during two hours in a melting heat in a crucible, to which a cover was luted, gave a very dark glaſs; from which was obtained a fine dark azure blue, by levigating it, and waſhing it with water, ſo as to ſeparate the leſs heavy parts.

(*b*) Half a dram of calcined cobalt, mixed with the former quantity of ſand and alkali, and treated in the ſame manner, gave a deep blue ſmalt, ſimilar to the above, and even of ſtill greater vivacity.

(*c*) With the ſame quantity of ſand and alkali, was mixed 15 grains of calcined cobalt. This gave likewiſe a fine lively blue colour, very little lighter than the former.

Theſe experiments prove at the ſame time that a portion of iron is not injurious to the preparation of ſmalt, if the cobalt is free from other ſubſtances.

The ſuppoſed Tungſten from Cornwall.

§ 1.

The true tungſten, or lapis ponderoſus, which now begins to be ſo very ſcarce, is known by its being fuſible, by a proper addition of microcoſmic ſalt, with the blow-pipe, and making a clear blue glaſs, but ſtill more certainly by its aſſuming a yellow colour when powdered, and digeſted with nitrous or marine acid.

Another, not leſs ſure way, to diſtinguiſh true tungſten from ponderous ſpar, quartz, and other ſtones, is by the hydroſtatical balance. The ſpecific gravity of tungſten in pure, compact, white

pieces,

pieces, dug formerly at Schlackenwalde and Schoenfeld, I found as 6015 : 1000.

Upon examination, the mineral ſent from Cornwall for tungſten proved not to be it. The following experiments will ſhew of what it conſiſts.

§ 2.

A part of this mineral, ſeparated from the adherent ochraceous iron ore, was mixed with an equal weight of fixed vegetable alkali, and expoſed in a crucible to a ſtrong heat. It did not melt, but was reduced to a powder, which while red hot, was poured out of the crucible, and obtained when it became cold, a dirty dark green colour, like the chamæleon minerale. By pouring water upon it, it ſhewed the ſame variety of colours as the alkalized manganeſe: the colour of the ſolution was at firſt graſs-green, but ſoon after violet in different ſhades. After being filtred and ſaturated with vitriolic acid, the colour became crimſon, and a ſmall brown precipitate was let fall, which, collected, proved to be calx of manganeſe, without any tungſtenic acid.

The dark brown powder which remained upon the filtre after the ſolution of the calcined maſs, being edulcorated, dried, and heated, was totally attracted by the magnet.

This analyſis ſufficiently ſhews this mineral to be iron mixed with manganeſe; on which account I have named it, "Liver-coloured haematites, mixed with manganeſe in ochraceous iron-ore."

Wolfram from Poldice.

§ 1.

Four ounces of wolfram well ſeparated from its ſtony matrix, were powdered, and

and mixed with an equal weight of fixed vegetable alkali, and melted in a crucible. It ſoon fuſed in a ſtrong heat, and a ſmell of arſenic was perceived. This dark green ſcoria-like maſs was poured upon a flat ſtone, reduced to a powder, and digeſted for a proper time in diſtilled water in a matraſs, and then filtred.

§ 2.

The reſiduum conſiſting of a looſe black powder, which weighed 10 drams, was again mixed with equal parts of fixed vegetable alkali and heated. Now no fuſion could be produced, but, it became only red hot. The water poured upon it afterwards diſſolved nothing, and took up only the alkali. This reſiduum when dried, proved to be a phlogiſticated calx of iron, attractable by the magnet.

§ 3.

The filtred colourless solution of the wolfram melted with alkali, was saturated by nitrous acid, by which the acid of wolfram was precipitated in form of a white tender earth. This precipitate washed and dried gave a yellowish white considerably heavy powder, and weighed 15 drams. If the acid of wolfram be precipitated when the solution of the alkalized wolfram is still warm, the mixture obtains a blue colour, which it loses again on growing cool.

§ 4.

The properties of this acid, and the effects it produced upon other substances, I found in general to agree with what Mr. *Scheele* has said, who is the discoverer of

it,

it, and whoſe merit in chemiſtry is ſo well known. However, what Mr. *Scheele* affirms, that this acid of wolfram or tungſten is ſoluble in 20 times its weight of water, is true only when the acid of wolfram is ſtill moiſt; for if it is in a ſtate of dry powder, ſcarcely 150 times its weight of water are ſufficient to diſſolve it. This acid is not ſtrong, having more of a diſagreeable metallic than ſour taſte. Its ſolution in water is very little altered by the phlogiſticated alkali, but does form after ſome time a little white precipitate. With lime-water and the ſolutions of calcareous and ponderous earth in marine acid, it forms an opal colour, and a white precipitate. The ſolutions of copper and iron are not altered by it; but ſilver, mercury, and tin, are precipitated white by it from their ſolutions. The precipitate of tin ſhews after ſome time a bluiſh green colour: If the dry acid of wolfram be employed, the ſolution of tin in marine acid is rendered

dered totally blue. With a ſolution of hepar ſulphuris made with fixed alkali it forms a green, and with that of hepar ſulphuris volatile a blue colour: the precipitates of both are blue.

§ 5.

Half an ounce of the dry acid of wolfram was digeſted for ſome time with 2 ounces of concentrated marine acid; it aſſumed a dark yellow ſulphur-like colour, and loſt 1 dram of its weight. The marine acid ſeparated by the filtre, and the water uſed for edulcorating the yellow reſiduum were mixed and ſaturated by fixed vegetable alkali: the ſolution became turbid, and formed a jelly-like precipitate, which, when dried, weighed 2 grains. In an open fire it was in part volatile with the ſmell of arſenic, and a ſcoria containing ſome iron was left. This ſhews that the white acid of wolfram ſtill

contains

contains ſome arſenic, which is alſo proved by other experiments. It melts with the blow-pipe, and yields a ſmoke of arſenic, and has the appearance of a ſteel-grey cryſtallized ſcoria: on the contrary, the acid of wolfram, of a yellow colour, prepared by digeſtion in marine acid, is infuſible with the blow-pipe, and ſhews no mark of arſenic, but the yellow changes into a bluiſh colour.

§ 6.

It is a peculiar property of this acid when melted with the microcoſmic ſalt, or other ſalts containing the phoſphoric acid in a proper proportion, to give them a fine blue colour, but it does not give a blue colour to borax. I made the two following experiments:

(a) Prepared ſilex,

Calcined borax, of each 2 drams,

Acid

Acid of wolfram, in a dry ſtate, 15 grains.

(*b*) Prepared ſilex, 1 dram,
Glacial phoſphoric acid, 2 drams,
Acid of wolfram, in a dry ſtate, 10 grains.

I found both melted to a glaſs in a proper degree of heat: (*a*), was of a fine cryſtalline colourleſs glaſs; (*b*), was alſo of a clear, tranſparent glaſs, but tinged with a fine ſapphire blue colour.

As therefore cobalt is not the only ſubſtance which communicates a blue colour to glaſs; this circumſtance muſt not be overlooked, in determining the diſpute with reſpect to the material the antients uſed in preparing their blue glaſs; cobalt as ſome aſſert, having been unknown to them.

§ 7.

Theſe properties ſhew evidently the acid of tungſten or wolfram to be metallic. If the ſuppoſition be true, that every ſubſtance of a metallic nature is capable of affording a regulus, we ſhould expect to obtain one from this acid. Nevertheleſs, Mr. De Luyart is the only perſon who has ſucceeded in producing a regulus. *My* experiments have hitherto failed, though I have attempted the reduction by different methods and different fluxes, both in common melting furnaces, and even in thoſe uſed for making porcelain at Berlin.

I juſt mention, that in theſe experiments I always made uſe of the yellow acid of wolfram; for I ſhould fear that the metallic globule obtained from the white unpurified acid, might be produced by a portion of iron and arſenic combined.

Soap-

Soap-rock from Cornwall.

§ 1.

One ounce of this ſoap-rock in pure pieces was heated to redneſs in a glaſs retort. In the receiver was found a ſmall quantity of pure taſteleſs water. It had loſt one dram 15 grains of its weight, and had acquired a darker colour, and a conſiderable degree of hardneſs. Pulverized and mixed with two ounces of fixed vegetable alkali, it was heated red hot in a crucible of porcelain, but not ſuffered to melt: after this, it was triturated with diſtilled water, and a ſuperabundant quantity of marine acid to ſaturate the alkali was added to it, and ſufficiently digeſted.

§ 2.

§ 2.

In the ſolution a precipitate was formed of a conſiderable quantity of white, looſe, yellow-like earth, which ſeparated, edulcorated, dried, and calcined, weighed 204 grains. It proved to be pure ſiliceous earth.

§ 3.

The ſolution being filtred and cryſtallized, phlogiſticated alkali was added to it, when it gave a blue precipitate, which collected upon the filtre, was edulcorated and dried. After heating it to redneſs with ſome wax, it weighed ſeven grains, and it was totally attracted by the magnet.

It would be an error to ſuppoſe theſe ſeven grains the true quantity of iron contained in this ſoap-ſtone. For, though the

the phlogiſticated alkali I uſe is ſo well prepared, that pure marine acid poured upon it does not ſhew the leaſt mark of blue during the firſt 24 hours, it nevertheleſs adds a portion of iron when uſed to precipitate iron diſſolved in acids. On account of this circumſtance, very great circumſpection is required, in determining the exact quantity of metal contained in a ſolution, and precipitated by phlogiſticated alkali.

I have found 100 parts of iron in a metallic ſtate, diſſolved in marine acid, and precipitated by pure fixed vegetable alkali, after being edulcorated and heated, to give 140 parts of phlogiſticated calx of iron attractable by the magnet: and the ſame quantity of iron, precipitated by cryſtallized phlogiſticated alkali, perfectly well prepared, the blue precipitate being edulcorated and heated, to give 260 parts of phlogiſticated calx of iron. The quantity of phlogiſticated alkali required for precipitating thoſe

100 parts of iron, diſſolved in marine acid, muſt then precipitate from itſelf ſo much iron as is equivalent to $85\frac{5}{7}$ parts of iron in a metallic ſtate, or 120 parts of calx of iron phlogiſticated by heating and attractable by the magnet.

According to theſe experiments, the quantity of iron in a ſtate of phlogiſticated calx contained in one ounce of ſoap-rock is $3\frac{10}{13}$ grains.

§ 4.

The earths of the ſolution were precipitated by cryſtallized fixed vegetable alkali, and, when edulcorated and calcined, weighed 192 grains. A proper quantity of diſtilled vinegar, ſomewhat concentrated by froſt, was added to this precipitate, and after digeſtion the ſolution was filtred. The earth remaining upon the filtre was dried again, and calcined, and then weighed 93 grains: it was afterwards treated with 3 times its weight of concentrated oil of vitriol, and evaporated nearly to dryneſs in a ſand-bath, then re-diſſolved in water and filtred. There then remained 26 grains of an indiſſoluble earth, which was ſilex: when this was mixed with mineral alkali, and melted with the blow-pipe, it ſwelled and gave a clear globule of glaſs.

I have ſeveral times obſerved ſiliceous earth along with other earths diſſolved in acids: this ſhould ſuggeſt how cautious a chemiſt ought to be in analyzing different kinds of ſtones and earths.

§ 5.

The vitriolic ſolution contained therefore the remaining 67 grains, which, precipitated by alkali and examined, was argillaceous earth.

§ 6.

§ 6.

Of the first quantity of earth, the weight of which was 192 grains (§ 4.) 99 grains were dissolved in acid of vinegar. Being precipitated by fixed vegetable alkali, and examined with the vitriolic acid, it was found to be magnesia.

§ 7.

One ounce or 480 grains of soap-rock contained therefore, according to the preceding experiments,

		grains.
Calcined earth of silex (§ 2.)	204 gr.	230
— — — — (§ 4.)	26 —	
— — — argill (§ 5.)	——	67
— — magnesia (§ 6.)	——	99
— calx of iron (§ 3.)	about	4
		400

The

The loſs of weight in air and water expelled by calcination — —	75
	475
Loſt during this proceſs — —	5
	480

FINIS.